Demand Uncertainty, Inventories, and Resale Price Maintenance

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I cannot believe that in the long run the public will profit by this course, permitting knaves to cut reasonable prices for mere ulterior purposes of their own, and thus to impair, if not destroy, the production and the sale of articles which it is assumed to be desirable the people should be able to get.

Justice Oliver Wendell Holmes, Jr., dissenting in
Dr. Miles Medical Co., v. *John D. Park & Sons Co.,*
220 U.S. 409 (1911).

This paper offers a new solution to an enduring puzzle in economics, that of why a manufacturer would prefer not to have its products sold by discounters. We offer a model of competitive retail pricing in the presence of demand uncertainty which demonstrates that a manufacturer may prefer to impose resale price maintenance (RPM) rather than allowing retailers to separate into niches defined by price and availability.[1] Under "niche competition," retailers must set retail prices and order inventories prior to the resolution of demand uncertainty. In equilibrium, the retail market is populated by discount retailers who offer relatively low prices with the assurance that they will sell their inventories even in low demand states, and higher price outlets that stand ready to sell in high demand states, knowing inventories will be unsold should demand be low.[2] Our model demonstrates how uniform pricing can support larger inventories and sales of the manufacturer's products, and in so doing provides a new explanation for manufacturer willingness to impose RPM. Mr. Justice Holmes' conclusion, quoted above and seemingly so at variance with economic logic, can thereby be shown to have a surprising theoretical underpinning.

The need for such a theory stems from a recent reinvigoration of the resale price maintenance controversy. Throughout its long and tortuous history, RPM has attracted passionate proponents and equally committed opposition.[3] Subsequent to the Supreme Court's 1911 decision to interpret RPM as vertical price fixing, and thereby to condemn it by analogy to purely horizontal price fixing, manufacturers and their distributor allies have argued that RPM is crucial to their ability to maintain distribution, and thus to the viability of their brands.[4]

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[1]We use the term "niches" to indicate that in equilibrium, retailers cater to different pockets of demand, each defined by its likelihood of occurrence. In our model, retailers have no monopoly power in any niche. Instead, competition in each niche occurs in Bertrand fashion.

[2]Our model thus has the advantage over the existing literature that discounting arises as an equilibrium phenomenon when manufacturers are not permitted to impose uniform retail prices using resale price maintenance.

[3]See Overstreet (1983) for a history of the controversy.

[4]The consistent thread in complaints about price cutting of branded products has been that such discounting

Discounters and consumer groups have replied that RPM denies consumers the benefits of efficient, low-cost distribution. While the controversy over RPM was muted in the 1980's, the antitrust authorities have recently begun aggressively to attack RPM schemes in a number of industries, with more activity promised.[5]

One important reason for the continuing wrangling over RPM is the absence of a theory capable of explaining its use for the "simple" products comprising an important fraction of RPM use (Ippolito and Overstreet, forthcoming). Such products do not require extensive demand-enhancing pre-sale services threatened by free riding.[6] In contrast to explanations based on services, our theory interprets RPM as a mechanism to increase the manufacturer's distribution in order better to serve existing demand, rather than to expand demand.[7] In our model, retailers simply choose prices and quantities without any added complications concerning service or quality. Our focus on RPM as a method for preserving distribution appears commonly

would impair brand-name distribution by causing retailers other than the discounter either to reduce inventories or to drop the product altogether. Examples of this position from early controversies over RPM can be found in United States, Federal Trade Commission, *Report of the Federal Trade Commission on Resale Price Maintenance* (Washington, D.C.: U.S. Government Printing Office, 1945), p. 7–9, 43ff. For examples from the 1960's see U.S., Senate, "Quality Stabilization," Hearings, 88th cong., 1964, particularly pp. 614ff., the statement of the Toilet Goods Association, pp. 619–20.

[5]The continuing widespread use of RPM is indicated by the range of recent RPM prosecutions, which have involved toys, athletic and casual shoes, hockey skates, indoor tanning products, and video games. As an FTC Commissioner notes, "there's a lot of clamor for additional enforcement in vertical price fixing cases." See "Starek Foresees Increased FTC Scrutiny over Vertical Restraints in Distribution." *Antitrust and Trade Regulation Report,* August 5, 1993, p. 199.

[6]Telser (1960) argues that the demand for a manufacturer's product will often depend on retailer-provided pre-sale services. Retailers will have an incentive to offer such services only if they can capture the demand the services generate. But if customers shop for the lowest price subsequent to obtaining service at a full service retailer, service-providing retailers will be at a competitive disadvantage relative to no-frills discounters who do not incur the cost of services and price accordingly. Free riding is often encouraged by discounters. (As one example, Wisconsin Discount Stereo advertised "It's easy to save! Just do your shopping (getting brand and model numbers.) Then call us and save $$." (*Audio,* May 1988, pp. 89-90.)) If enough customers sought services at one retail firm and purchased at a discount rival, the high-service retailer would reduce or eliminate services, constricting the demand for the manufacturer's product.

The free-rider theory requires that candidate products for RPM have characteristics about which retailers can offer useful advice, and suggests that RPM is most likely when products are newly introduced, so that consumers are ill-informed. Our model explains RPM use for cases where services appear absent, including familiar, uncomplicated products with pronounced demand uncertainty, such as items with strong seasonal demand components. In our model, RPM increases retail inventories, not a retail activity threatened by free riding. A consumer cannot make a selection from a store with a large inventory and then confidently go to a limited-availability discount outlet to purchase that item.

[7]A recent paper by Winter (1993) has shown that with consumer heterogeneity, excessive retailer emphasis of price competition over service competition can lower the final demand for the manufacturer's product, even if the services in question are not subject to free riding. Our approach relies neither on demand-enhancing services nor on heterogeneous customers, and hence differs substantially from Winter's. Instead, we argue that excessive retailer price competition results in a decreased supply of the manufacturer's product to the market. Our emphasis on maintaining adequate retail inventories appears appropriate, since this problem is the principal stated concern of manufacturers in the case studies below. See also note 6 above.

in manufacturer justifications for their use of the practice. For example, one careful study of a case involving Corning cookware (Ippolito and Overstreet, forthcoming) finds both that the stated motivation for Corning's use of RPM was to increase distribution, and that sales fell relative to those of competitors when Corning's RPM use was prohibited.

Our paper provides a theoretical explanation for why RPM could benefit both consumers and manufacturers when Holmes' "knaves" would otherwise have destroyed the manufacturers' distribution. But in contrast to other efficiency-based theories of RPM, theories in which manufacturer and consumer interests roughly coincide, we show that manufacturer benefits can often come principally from consumer surplus. Manufacturers may still wish to suppress discounting even if high price retailers would not have abandoned their products; in such cases, consumers may prefer that discounters be permitted to flourish.

The following elements are central to our theory:

- uncertainty over the demand for the manufacturer's product,
- the manufacturer's need for its product to be on retailer shelves before that uncertainty is resolved, and
- retailers must incur some costs of unsold inventory.

These elements are particularly prominent in recent manufacturer attempts to achieve control over resale prices through the use of minimum advertised pricing (MAP) promotions. MAP plans are a form of cooperative advertising arrangement under which the manufacturer agrees to pay a rebate to dealers, at least nominally intended to reimburse dealers for dealer advertising featuring the manufacturer's product.[8] The MAP provision requires that in order to receive such rebates, a dealer must not advertise a price lower than that specified by the manufacturer. This form of RPM enforcement was of doubtful legality up until 1990, but with recent FTC approval, MAP plans have spread rapidly. Products now covered by MAP plans include video recordings of movies sold rather than rented to consumers (sell-through videos),[9]

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[8]FTC rules require that the "seller should take reasonable precautions to see that the services the seller is paying for are furnished...." See U.S. Federal Trade Commission, 16 CFR Part 240, Guides for Advertising Allowances and Other Merchandise Payments and Services, 55 FR 33651, August 17, 1990. Comments received by the FTC indicate that its rules were believed likely to result in RPM, an expectation that has been fulfilled.

[9]MAP pricing now covers virtually all such video sales, a development that dates from an FTC policy statement that MAP would be evaluated as a rule-of-reason matter. See Seth Goldstein, "Picture This," *Billboard,* July 30, 1994, p. 72, and Dan Alaimo, "Price Points: Roundtable Participants Sound Off on MAP, McDonald's Video Promotions, and Other Pricing Issues," *Supermarket News,* May 22, 1995.

compact disks,[10] women's apparel,[11] and toys.[12] The MAP plans, focused as they are on dealer price and availability advertising, indicate that retailers commit to prices in advertising placed prior to the demand period. The demand period is often particularly brief for videos and CD's, sales of which are tied to extensive advertising campaigns undertaken by the manufacturer. The substantial advertising campaigns mounted for such products require that they be on retail shelves awaiting consumers motivated to shop by advertising exposure. The manufacturer's willingness to pay retailers for retailer promotional advertising and services, together with large manufacturer advertising campaigns, indicates that the manufacturers can deal directly with potential free rider problems. Finally, demand uncertainty is substantial. Even a theatrical hit like "Wayne's World" has lead to millions of unsold videocassettes.[13] Clearly the demand for fashion and fad products generally is difficult to predict with precision.

We proceed as follows. Section 1 models retailer competition assuming that the value consumers place on the manufacturer's product is known, but the number of customers is uncertain. Section 2 generalizes the analysis to arbitrary demand and introduces positive costs of manufacturing and distribution. Section 3 discusses the welfare effects of permitting RPM and illustrates why consumers may oppose RPM that increases total welfare. While we are primarily concerned with markets in which retailers must commit to prices prior to the realization of demand, Section 4 suggests that our conclusions remain valid when the retail price is determined by market clearing. Section 5 analyzes a historical example of RPM use in which the characteristics of the market closely fit our model. We also discuss a very prominent recent use of a MAP policy to control retail prices, namely the introduction of Microsoft Windows 95. Section 6 summarizes the results and considers their implications for the political economy of RPM.

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[10]See Ed Christman, "MAP Policies Tackled," *Billboard,* March 11, 1995. CD computer game and software MAP programs are now emerging as well. See Jane Greenstein, "Battle for Shelf Space Puts Publishers in Financial Bind," *Video Business,* July 7. 1995, p. 42.

[11]Alice Welsh, "Rider's Mass Momentum (Lee Apparel's Riders Brand Gets Mass Market Expansion)," *WWD,* January 19, 1995.

[12]"Toy Maker Settles Charges of Vertical Price Fixing," *Antitrust and Trade Regulation Report,* v. 68, no. 1698, February 2, 1995, p. 132.

[13]" 'Gump' Vid Gets $10 Mil TV Push," *Hollywood Reporter*, February 6, 1995.

1 Fixed Reservation Prices

To illustrate why manufacturers might wish to prevent discounting of their products, we start by describing our framework and presenting a simple example. Consider a risk-neutral monopoly manufacturer of a well-established branded product that sells to a large number of risk neutral, perfectly competitive retailers.[14] More precisely, we assume that there is a continuum of retailers, indexed by $t \in [0, 1]$. The manufacturer faces a constant marginal cost of production, c^w. We assume that retailers have a constant marginal cost of inventory holdings, c_1^r, and constant marginal cost of sales, c_2^r, and without loss of generality normalize them to be zero.[15] We assume that the final demand for the manufacturer's product is random.

Prior to the resolution of this demand uncertainty, the manufacturer must set p^w and the retailers must order their inventories.[16] We assume that unsold merchandise has no scrap value.[17] This implies that retailers face a tradeoff in choosing their level of inventory: larger inventories increase sales in high demand states, but produce greater losses in low demand states. We compare two methods of choosing retail prices: niche competition and RPM.

The Niche Competition Game. First, the manufacturer sets the wholesale price. Next, retailers choose simultaneously what retail price to set and how much inventory to hold. Finally, demand is realized. Demand is allocated to the lowest priced firm first; residual demand, if any, goes to the next lowest priced firm, and so forth.

The RPM Game. First, the manufacturer sets its wholesale price, p^w, and the retail price at

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[14]We follow the RPM literature in assuming that the manufacturer has some degree of monopoly power arising from its brand. But even were the manufacturer to sell its product at marginal cost, the inefficiency we identify persists. Hence, if RPM were legal, manufacturers would choose unilaterally to impose RPM.

[15]Inventory holding costs can be absorbed into the manufacturer's production cost, and the cost of providing sales is handled by reinterpreting inverse demand as willingness to pay above c_2^r. Starting with positive distribution costs, we have an equivalent model with zero distribution costs, marginal production costs $c^w + c_1^r$, and willingness to pay $p(q, \alpha) - c_2^r$ (where $p(q, \alpha)$ is willingness to pay in the original model and α is the demand shock).

[16]This assumption reflects the reality that in many markets production lags are significant, and that consumers prefer to purchase substitutes rather than wait until inventories have been replenished.

[17]It is sufficient for our purposes that the retailer cannot recoup its full original purchase cost if it is left with excess inventory at the end of the period. Inventory holding costs are perhaps the most direct source of such sunk investment. When inventory holding costs are insignificant, we are implicitly assuming that no return option exists once the retailer has taken title to the manufacturer's products. In our model, introducing a costless return option duplicates the RPM outcome, but only as long as production is costless. With costly production, a policy of accepting returns for full credit provides retailers with an incentive to order for all possible demand states, despite the manufacturer's desire not to produce for low probability states. In practice, return systems are typically quite costly, requiring that shipping charges be incurred and that returned merchandise be counted and credited by the manufacturer.

which its product is resold, p^r. Next, retailers choose simultaneously how much inventory to hold, prior to the resolution of uncertainty. Finally, demand is realized. Consumers, indifferent among retailers, are assumed to choose firms so as to equate the ratio of sales to inventory across firms. That is, when there is excess supply, the probability of any unit being sold is the same for all firms.

For our example, we make the following assumptions. Manufacturing is costless, $c^w = 0$. Every consumer has the same reservation value, $v = 1$, which is the same in every state of the world. The number of customers that arrive is uncertain. Three equal probability states are possible, indexed by $i = 1, 2, 3$. Our assumed demand conditions are as indicated in Table 1.

Table 1: Characterization of Demand

State	1	2	3
Number of arrivals, d_i	1	2	3
Probability of state	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$

1.1 Analyzing the Niche Competition Game

Given the wholesale price, the retail market subgame of the niche competition game described above is essentially the "hotels" model of Prescott (1975), also studied by Bryant (1980), Lucas and Woodford (1992), Eden (1990), and Dana (1993). If p^w is low enough, then Nash equilibrium entails retail market segmentation. Low price retailers are able to sell their entire inventories, but will often stock out. High price retailers will stock inventories to be sold in high demand states, but will be left with unsold inventories when demand is low. In equilibrium, expected profits are zero in each niche. The intuition is that positive profits earned by any retailer would invite rival firms to undercut the profitable firm's price to acquire those profits.

The following strategies constitute an equilibrium to the retail subgame, given $p^w \leq 1$. Retailers $t \in [0, 1/3)$ each stock $q(t) = 3$ at a retail price equal to the wholesale price, $p_1^r = p^w$. (The total quantity stocked at the price p^w integrates to 1 unit.) Retailers $t \in [1/3, 2/3)$ each

stock $q(t) = 3$ whenever $p^w \leq 2/3$ and stock zero otherwise; each sets a retail price given by $p_2^r = 3p^w/2$. Retailers $t \in [2/3, 1]$ each stock $q(t) = 3$ if $p^w \leq 1/3$ and zero otherwise; each sets a retail price given by $p_2^r = 3p^w$. The configuration of prices and aggregate quantities is given in Table 2. Thus, if $p^w \leq 1/3$, three units are offered, with one each at p_1^r, p_2^r and p_3^r.

Table 2: The Wholesale Demand Curve under Niche Competition

Wholesale price				Retail Inventory	Retail Price of Incremental Unit
2/3	<	p^w	≤ 1	One unit stocked	$p_1^r = p^w$
1/3	<	p^w	≤ 2/3	One *additional* unit stocked	$p_2^r = \dfrac{3p^w}{2}$
		p^w	≤ 1/3	One *additional* unit stocked	$p_3^r = 3p^w.$

To see that the above strategies constitute a Nash equilibrium to the retail subgame, notice that all retailers are earning zero (expected) profits. Any deviation to any quantity at one of the prices p^w, $\dfrac{3p^w}{2}$, or $3p^w$ continues to earn retailer t zero profits. Any deviation to a positive quantity at a retail price other than p^w, $\dfrac{3p^w}{2}$, or $3p^w$ leads to negative profits—retailer t could instead raise the retail price and not lose any customers in any state.[18] Therefore, no retailer has a profitable deviation.

We claim that the above configuration of prices and aggregate quantities is the unique equilibrium configuration. The lowest retail price must be p^w, for otherwise (much like in ordinary Bertrand competition) noninfinitesimal profit opportunities exist for a firm that undercuts the lowest price. At the retail price equal to p^w, the total quantity supplied must be one; a higher quantity leads to negative profits and a lower quantity leads to residual demand and noninfinitesimal profit opportunities. Given one unit is offered at the retail price equal to p^w, if a positive quantity is offered at a higher retail price, that price must be $\dfrac{3p^w}{2}$.[19] A lower retail price yields negative profits. A retail price higher than $3p^w/2$ is either greater than one, and therefore inconsistent with equillbrium, or results in noninfinitesimal profit opportunities which induce undercutting. As above, if a positive quantity is offered at the

[18]Because there is a continuum of retailers, no single retailer faces positive residual demand, so there is no incentive to raise the retail price. Our equilibrium, then, might not be the limit of equilibria in markets with a finite number of retailers, since residual demand exists away from the limit. This inelegant feature is removed if we slightly perturb the timing of the niche competition game, so that retailers first simultaneously choose their retail prices, followed by simultaneously choosing their quantities.

[19]A positive quantity will be offered only if $3p^w/2 \leq 1$. If $3p^w/2 > 1$, no units will be demanded at a retail price in excess of 1, and any lower retail price yields negative profits.

price $3p^w/2$, that quantity must be exactly one. By the same reasoning, given the behavior in the lower price niches, if a positive quantity is offered at a retail price higher than $\dfrac{3p^w}{2}$, that price must be $3p^w$ and the quantity offered must be exactly one.[20]

Having solved the retail subgame, we may now characterize the full equilibrium. Clearly, the manufacturer will choose the highest p^w consistent with a given aggregate inventory level, q^w, yielding three possibilities. If $p^w = 1$, only the certain demand is served, and we have $p_1^r = 1$, $q^w = 1$, and manufacturer profits, denoted Π^w, are given by $\Pi^w = 1$. If $p^w = 2/3$, two demand niches are served and we have $p_1^r = 2/3$, $p_2^r = 1$, $q^w = 2$, and $\Pi^w = 4/3$. Finally, if $p^w = 1/3$, all three demand niches are served. We have $p_1^r = 1/3$, $p_2^r = 2/3$, $p_3^r = 1$, $q^w = 3$, and $\Pi^w = 1$.

It is apparent that the manufacturer chooses to serve two niches with a wholesale price of $2/3$. The retail price for niche 2 is 1; customers who purchase at this price do not receive any surplus. Niche 3 generates no surplus since it is never served. Niche 1 retailers always sell out their stocks of the good and these sales always generate consumer surplus of $1/3$. Expected consumer surplus is therefore $1/3$.

1.2 Analyzing the RPM Game

If the manufacturer is able to impose resale price maintenance, discount niches cannot emerge. Clearly, the optimal retail price will be $p^r = 1$, for this price extracts all surplus in each state. Given the manufacturer's wholesale price, retailers compete by ordering aggregate inventories, $q^w = \int_0^1 q(t)\,dt$, up to the point where all retail profits are dissipated. More precisely, q^w is determined as the solution to $\frac{1}{3}\min(1, q^w) + \frac{1}{3}\min(2, q^w) + \frac{1}{3}\min(3, q^w) - p^w q^w = 0$. The manufacturer's wholesale demand is therefore as shown in Table 3.

It is easily checked that the manufacturer optimizes by setting $p^w = 2/3$, yielding $q^w = 3$ and $\Pi = 2$. Since retailers make zero profits in any event,[21] the manufacturer receives all the

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[20]This uniqueness argument applies to mixed-strategy as well as pure-strategy Nash equilibria, as long as the aggregate configuration of prices and quantities is deterministic (due to a version of the law of large numbers). It can be shown, for this example, that a symmetric mixed-strategy Nash equilibrium also exists, yielding the same aggregate configuration.

[21]Aggregate equilibrium inventories are uniquely determined. Any distribution of inventories across retailers represented by a finite-valued, measurable (and therefore integrable) function $q(t)$ whose integral equals q^w is consistent with equilibrium.

Table 3: The Wholesale Demand Curve under RPM

Wholesale Price				Retail Inventory
$5/6$	$<$	p^w	$\leq \quad 1$	$\dfrac{1}{3p^w - 2}$
$2/3$	$<$	p^w	$\leq \quad 5/6$	$\dfrac{3}{3p^w - 1}$
		p^w	$\leq \quad 2/3$	$\dfrac{2}{p^w}$

surplus.[22] Consequently, the manufacturer will prefer to induce full stocking.

RPM benefits the manufacturer in this example, since the wholesale price remains unchanged as inventory holdings increase by 50%. Note also that total surplus under resale price maintenance (2) exceeds the sum of manufacturer profits $\left(\dfrac{4}{3}\right)$ and expected consumer surplus $\left(\dfrac{1}{3}\right)$ under niche competition. RPM yields a welfare optimum.

This simple example shows that manufacturers prefer not to have discounters carry their product simply because the discounters inhibit the willingness of higher-priced dealers to hold stocks. Indeed, a direct comparison of Tables 2 and 3 shows that the imposition of RPM has shifted out the entire wholesale demand schedule. Retailers are competitive in any event, so their interests play little or no role in our model. However, in contrast to the free-rider model of resale price maintenance, the manufacturer's desire to inhibit discounting is not in the consumer's interest. As long as most surplus is extracted by the manufacturer's required resale price, consumers will prefer the uncertain prospect of a discount price to assured availability of a good that does not yield surplus.

It is instructive to trace through the process by which unrestrained retail competition destroys wholesale demand. Suppose the manufacturer keeps the wholesale price at the RPM optimum, $p^w = 2/3$,[23] but frees up the retail price. A discounter stocking one unit will then find it profitable to undercut the retail price of $p^r = 1$. Since consumers will always buy from the lowest-priced retailer first, the discounter is assured to sell this unit, and thereby earn positive profits. Other discounters will follow, driving the retail price in the first niche

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[22]It is straightforward to show that our "competitive" RPM solution is the limit of Nash equilibria of the finite RPM game, where the number of retailers approaches infinity.

[23]The same reasoning can be applied for any wholesale price, explaining the shift in the wholesale demand curve. Theorem 2 shows that the argument generalizes to arbitrary demand, costs, and uncertainty.

down to $p_1^r = 2/3$, where no further profits can be earned. Meanwhile, stores not discounting will lose money, since they can no longer sell during low demand states. Indeed, with their collective orders equal to 2 (q^w minus niche 1 demand served by discounters), expected profits will be equal to -1/3. By reducing their orders by one unit, expected revenues decline by 1/3 (revenue in state 3 declines by one unit), but costs decline by 2/3, restoring profitability. The manufacturer, however, loses since its wholesale price is unchanged as wholesale demand declines.

2   The General Demand Specification

Section 1 provided an example with rectangular demand and common reservation prices to show that the manufacturer prefers RPM over unrestrained retail competition. Without RPM, discount retailers are first in line to serve demand, and hence lower the probability of sale of the remaining retailers. To be profitable, those attempting to sell to high demand niches are forced to raise their prices. Since the retail price under RPM was already set at the highest possible level (the reservation price), niche competition results in fewer niches served. The absence of a demand expansion effect resulting from lower retail prices then implies that the manufacturer's wholesale demand declines. But while compelling, this intuition is clearly tied to the common reservation price beneath which demand is inelastic. This section generalizes our results to arbitrary demand. We also allow arbitrary distributions over states of the world, and permit production and distribution to be costly (see note 15).

Without loss of generality, let there be a continuum of possible demand states. Demand in state α is indicated by $d(p, \alpha)$ and is monotone in the following sense: $d(p, \alpha) > 0$ implies $d(p, \alpha') > d(p, \alpha)$ for all $\alpha' > \alpha$. We further assume that $d(p, \alpha)$ is jointly continuous in (p, α), and that for each α there exists $\hat{p}(\alpha) \in (0, \infty)$ such that $d(p, \alpha) > 0$ for $p < \hat{p}(\alpha)$ and $d(p, \alpha) = 0$ for $p \geq \hat{p}(\alpha)$. The state of the world is distributed according to the (nondegenerate) distribution function $F(\alpha)$, whose support is contained in a bounded interval $[\underline{\alpha}, \bar{\alpha}]$. We make no assumptions on $F(\alpha)$; hence discrete, absolutely continuous, and mixed distributions are allowed.

Our model of retail competition allows price dispersion to arise in equilibrium. When firms charge different prices, consumers buy from the cheapest suppliers first. If those firms cannot satisfy all demand, some customers will remain for higher-priced firms. How much those firms can actually sell depends on how the output of lower-priced firms is rationed. We assume that demand is rationed efficiently in the sense that the segments of demand that are willing to pay the most are matched to the lowest prices.[24] Consequently, firms charging the price p in state α face industry demand at that price less the quantity supplied by lower-priced firms:

$$q(p, \alpha) = \max\{0, d(p, \alpha) - Q(p)\}. \tag{1}$$

Thus $Q(p)$ denotes the cumulative inventory holdings by retailers charging prices strictly below p.

2.1 The Retail Subgame under Niche Competition

Define $G(\alpha) = \lim_{\alpha' \uparrow \alpha} F(\alpha')$. Then $(1 - G(\alpha))$ denotes the probability that the state is greater than or equal to α. To describe the equilibrium in the retail subgame, we can compute, for each niche α,

$$p(\alpha) = \frac{p^w}{1 - G(\alpha)}. \tag{2}$$

$$Y(\alpha) = \max_{\alpha' \leq \alpha} d(p(\alpha'), \alpha'). \tag{3}$$

Equations (2) and (3) have the following interpretation. Given the manufacturer's choice of a wholesale price p^w, $p(\alpha)$ denotes the retail price charged by firms serving niche α, and $Y(\alpha)$ denotes the total inventories held by firms selling to demand pockets less than or equal to α.

The explanation of (2) and (3) is most straightforward when $F(\alpha)$ is strictly increasing and continuous, so that $p(\alpha)$ is strictly increasing and continuous. Consider a retailer catering to niche α, and therefore charging the price $p(\alpha)$. By (3), whenever the state is below α,

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[24]The details of the rationing rule do not matter when demand is rectangular, although they can be important when demand is elastic. For example, first-come-first-served (FCFS) rationing yields larger residual demand than efficient rationing when demand is elastic. The general solution to the niche competition game with FCFS rationing is complicated, but we have verified that when demand uncertainty is multiplicative (see equation (17) below) and $c^w = 0$ the equilibrium inventories and manufacturer profits are higher under RPM. Furthermore, the welfare results parallel those given in Theorem 5 below. Our conclusions therefore appear to be robust with respect to the choice of the rationing rule.

residual demand at the price $p(\alpha)$ equals zero. With probability $F(\alpha)$, our firm will therefore be unable to sell, and lose p^w per unit of inventory held. Suppose now that there is some residual demand in state α, so that $d(p(\alpha), \alpha') > Y(\alpha)$ for all $\alpha' > \alpha$. Our retailer can sell whenever the state exceeds α, and hence with probability $(1 - F(\alpha))$ earns $[p(\alpha) - p^w]$ per unit of inventory held.[25] Competition between retailers forces expected profits per unit of inventory to be zero, as expressed in (2), and pushes inventory levels to the point where $Y(\alpha) = d(p(\alpha), \alpha)$, as expressed in (3). Of course, if the price $p(\alpha)$ increases too fast relative to α, there may be no residual demand in state α. This idea is also embedded in (3): for states of the world α such that $Y(\alpha) > d(p(\alpha), \alpha)$, no retailer serves niche α.

Equations (2) and (3) define the equilibrium retail supply function $Q(p)$ parametrically in α. Specifically, upon letting $\hat{\alpha}(p) = \sup\{\alpha : p(\alpha) < p\}$,[26] we have:

$$Q(p) = Y(\hat{\alpha}(p)). \tag{4}$$

Despite the complexity of the retail equilibrium under niche competition, the manufacturer's wholesale demand actually takes on a very simple form:

$$q_N^w(p^w) = Y(\bar{\alpha}) = \max_{\alpha} d(p(\alpha), \alpha). \tag{5}$$

Note that $d(p(\alpha), \alpha)$ is an upper semicontinuous function,[27] so that $q_N^w(p^w)$ and $Y(\alpha)$ are well defined.

2.2   The Retail Subgame under RPM

Given the manufacturer's choice of a wholesale price, p^w, and a retail price, $p^r \geq p^w$, retailers increase their inventories until retail profits are zero. For any aggregate level of inventory

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[25]When α is a point of discontinuity of F and there is residual demand in state α at the price $p(\alpha)$, the relevant probability of sale is $(1 - G(\alpha))$. Finally, on any interval where F is constant, the price $p(\alpha)$ is constant, so that there are multiple niches facing the same retail price. If we let $\alpha^1 = \sup\{\theta \in \text{supp } F : p(\theta) = p(\alpha)\}$, then the proper interpretation of (2) and (3) is that all retailers charging the price $p(\alpha)$ serve niche α^1.

[26]We use the convention that $\sup(\varnothing) = -\infty$ and define $Y(\alpha) = 0$ for $\alpha < \underline{\alpha}$.

[27]The function $p(\alpha)$ is left continuous and increasing, and hence lower semicontinuous. The monotonicity of $d(p, \alpha)$ in p, and its continuity in (p, α), then imply that $d(p(\alpha), \alpha)$ is upper semicontinuous in α.

holdings y, retail profits may be expressed as

$$\Pi^r(y, p^r, p^w) = p^r \left[\min\{d(p^r, \underset{\sim}{\alpha}), y\} F(\underset{\sim}{\alpha}) + \int_{\underset{\sim}{\alpha}}^{\bar{\alpha}} \min\{d(p^r, \alpha), y\} dF(\alpha) \right] - p^w y, \quad (6)$$

where the integral in (6) is to be interpreted as a Stieltjes integral. The function Π^r is contin-uous, concave in y,[28] satisfies $\Pi^r \geq 0$ at $y = d(p^r, \underset{\sim}{\alpha})$, and has $\lim_{y \to \infty} \Pi^r(y, p^r, p^w) = -\infty$ for any $p^w > 0$. Consequently, aggregate retail demand at the prices (p^r, p^w) must satisfy:[29]

$$q^r_{RPM}(p^r, p^w) = \sup\{y \geq 0 : \Pi^r(y, p^r, p^w) \geq 0\}. \quad (7)$$

The nonuniqueness of roots to the equation $\Pi^r = 0$ unfortunately destroys the continuity of the function q^r_{RPM}.[30] However, it is easily checked that q^r_{RPM} is upper semicontinuous.[31]

2.3 Comparing the Manufacturer's Profits

Under niche competition, the manufacturer's wholesale demand is given by (5). Manufacturer profits are therefore equal to

$$\Pi^w_N = \max_{p^w, \alpha} (p^w - c^w) d \left(\frac{p^w}{1 - G(\alpha)}, \alpha \right) \quad (8)$$

Under RPM, the manufacturer earns

$$\Pi^w_{RPM} = \max_{p^r, p^w} (p^w - c^w) q^r_{RPM}(p^r, p^w). \quad (9)$$

---

[28]For $y \leq d(p^r, \underset{\sim}{\alpha})$, $\partial \Pi^r / \partial y = (p^r - p^w)$, and for $y > d(p^r, \bar{\alpha})$, $\partial \Pi^r / \partial y = -p^w$. For $y \in [d(p^r, \underset{\sim}{\alpha}), d(p^r, \bar{\alpha})]$, Π^r may not be differentiable in y, but does have a left-hand derivative equal to $[(1 - G(\alpha))p^r - p^w]$, and a right-hand derivative equal to $[(1 - F(\alpha))p^r - p^w]$. Since each of the latter two functions is declining, and since $(1 - F(\alpha)) \leq (1 - G(\alpha))$, we conclude that Π^r is concave in y.

[29]Note that $\Pi^r = 0$ at $y = 0$, so that it is necessary to take the largest root in (7). Note also that if $p^r > 0$ and $p^w = 0$, then $\Pi^r(y, p^r, p^w) > 0$ for all $y < \infty$, so that the supremum in (7) cannot be replaced by a maximum.

[30]The simplest example occurs when $p^r = p^w > 0$, in which case any $y \in [0, d(p^r, \underset{\sim}{\alpha})]$ solves $\Pi^r = 0$, and any $y > d(p^r, \underset{\sim}{\alpha})$ has $\Pi^r < 0$. Our definition then yields $q^r_{RPM} = d(p^r, \underset{\sim}{\alpha})$. However, if p^w is increased slightly, then $q^r_{RPM} = 0$.

[31]Let $y_n = q^r_{RPM}(p^r_n, p^w_n)$, and suppose that $(y_n, p^r_n, p^w_n) \to (y, p^r, p^w)$. Then if $p^w > 0$, we have $0 = \lim_{n \to \infty} \Pi^r(y_n, p^r_n, p^w_n) = \Pi^r(y, p^r, p^w)$. Consequently, (7) yields $q^r_{RPM}(p^r, p^w) \geq y = \lim_{n \to \infty} q^r_{RPM}(p^r_n, p^w_n)$. If $p^w = 0$, then $q^r_{RPM}(p^r, p^w)$ is infinite, so that the same inequality holds.

Note that the domain of potential optimizers in (8) and (9) is compact, and that the objective functions are upper semicontinuous. A maximum is therefore guaranteed to exist, but need not be uniquely attained.

Before stating our main result, we slightly strengthen the monotonicity of demand in the state as follows:

$$\frac{\partial d}{\partial \alpha}(p, \alpha) > 0 \text{ for every } (p, \alpha) \text{ such that } d(p, \alpha) > 0. \tag{10}$$

Theorem 1 *The manufacturer's profit under RPM is always at least as high as under niche competition. Furthermore, if (10) holds and F is strictly increasing and absolutely continuous, then except for the trivial case in which c^w is so high that $\Pi_N^w = \Pi_{RPM}^w = 0$, the manufacturer's profits under RPM are strictly higher than under niche competition.*

Proof: Since the manufacturer will never set a wholesale price which leaves retailers with positive profits, we may use (7) to rewrite (9) as

$$
\begin{aligned}
\Pi_{RPM}^w &= \max_{p^r, y} p^r \left\{ d(p^r, \underline{\alpha}) F(\underline{\alpha}) + \int_{\underline{\alpha}}^{\bar{\alpha}} \min \left[d(p^r, \theta), y \right] dF(\theta) \right\} - c^w y \\
&= \max_{p^r, \alpha} p^r \{ d(p^r, \underline{\alpha}) F(\underline{\alpha}) + \int_{\underline{\alpha}}^{\alpha} d(p^r, \theta) dF(\theta) \} + \\
&\qquad d(p^r, \alpha) \{ (1 - F(\alpha)) p^r - c^w \} \\[4pt]
&\geq \max_{p^r, \alpha} d(p^r, \alpha) \{ (1 - G(\alpha)) p^r - c^w \} \\[4pt]
&= \max_{p^w, \alpha} d\left(\frac{p^w}{1 - G(\alpha)}, \alpha \right) (p^w - c^w) \\[4pt]
&= \Pi_N^w.
\end{aligned}
$$

$$\tag{11}$$
$$\tag{12}$$

The inequality above obtains because for each (p^r, α), the maximand in (11) is at least as high as the maximand in (12). Suppose now that $\Pi_N^w > 0$, and let (p^r, α) attain the maximum in (12). Now equality in (12) can hold only if (p^r, α) also belongs to the arg max of (11). In addition, if F has full support, we must have $\alpha = \underline{\alpha}$, since $\alpha > \underline{\alpha}$ and $\Pi_N^w > 0$ imply $p^r \{ d(p^r, \underline{\alpha}) F(\underline{\alpha}) + \int_{\underline{\alpha}}^{\alpha} d(p^r, \theta) dG(\theta) \} > 0$. However, upon differentiating the maximand of

(11) with respect to α, and evaluating the expression at $(p^r, \underline{\alpha})$, we obtain[32]

$$\frac{\partial(\text{maximand of (11)})}{\partial \alpha} = \frac{\partial d}{\partial \alpha}(p^r, \underline{\alpha})(p^r - c^w).$$

Since $\Pi_N^w = d(p^r, \underline{\alpha})(p^r - c^w) > 0$, increasing α increases RPM profits, so we obtain a contradiction to the supposition that $(p^r, \underline{\alpha})$ is in the arg max of (11). Finally, if $\Pi_N^w = 0$, we conclude that $\Pi_{RPM}^w \geq \Pi_N^w = 0$. ∎

At this point, the reader may be somewhat perplexed as to why Theorem 1 holds, especially at the level of generality we allowed. To understand this, it is useful to define the demand facing the manufacturer when he sets a wholesale price of p^w and selects p^r optimally:

$$q_{RPM}^w(p^w) = \max_{p^r} q_{RPM}^r(p^r, p^w). \tag{13}$$

As demonstrated by the example in Section 1, it is still the case that RPM shifts out the manufacturer's wholesale demand schedule:

Theorem 2 *For every p^w, we have $q_{RPM}^w(p^w) \geq q_N^w(p^w)$.*

Proof: Let $\tilde{\alpha}$ be such that $d\left(\dfrac{p^w}{1 - G(\tilde{\alpha})}, \tilde{\alpha}\right) = q_N^w(p^w) \equiv y_N$, and let $\tilde{p}^r = \dfrac{p^w}{1 - G(\tilde{\alpha})}$. Suppose that the manufacturer sets the RPM price equal to $\tilde{p}^r$. Then at $y = y_N$, we have

$$
\begin{aligned}
\Pi^r(y_N, \tilde{p}^r, p^w) &= \tilde{p}^r \left\{ d(\tilde{p}^r, \underline{\alpha})F(\underline{\alpha}) + \int_{\underline{\alpha}}^{\tilde{\alpha}} \min\{d(\tilde{p}^r, \theta), y_N\} dF(\theta) \right\} - p^w y_N \\
&\geq y_N\{\tilde{p}^r(1 - G(\tilde{\alpha})) - p^w\} = 0.
\end{aligned}
$$

Definition (7) then implies that $q_{RPM}^w(p^w) \geq q_{RPM}^r(\tilde{p}^r, p^w) \geq y_N$. ∎

The intuition behind Theorem 2 lies at the heart of our paper. Under niche competition, the retail price in each active niche satisfies $p(\alpha)(1 - G(\alpha)) = p^w$. Hence each active retailer earns an expected revenue of $p(\alpha)(1 - G(\alpha)) = p(\tilde{\alpha})(1 - G(\tilde{\alpha}))$ per unit of inventory held.

---

[32]This is where we use the absolute continuity of F. If $F(\underline{\alpha}) > 0$, then the right-hand derivative still exists and is equal to $\dfrac{\partial d}{\partial \alpha}(p^r, \underline{\alpha})[p^r(1 - F(\underline{\alpha})) - c^w]$. If $[p^r(1 - F(\underline{\alpha})) - c^w] \leq 0$, then it is possible that under both RPM and niche competition, only the lowest possible niche is served, yet profits from doing so are not zero. We have verified this possibility in a two-state linear demand example with multiplicative uncertainty.

Aggregate expected retail revenues are therefore as if each retailer sold at the highest available price under niche competition, $p(\tilde{\alpha})$, but only when the demand at this price exceeds the aggregate inventory level. By setting the RPM price at $p(\tilde{\alpha})$, the manufacturer ensures that retailers collect the same amount of revenue when demand exceeds the aggregate inventory level, but at the same time allows them to collect revenues in lower demand states. This extra revenue gets competed away in the form of higher inventory demand. Adjusting the RPM price to the optimal level can only further increase the manufacturer's wholesale demand.

A careful analysis of the proof of Theorem 2 shows that if F is strictly increasing, and if under niche competition more than the lowest niche (the sure level of demand) gets served, then $q^w_{RPM}(p^w) > q^w_N(p^w)$. If under niche competition only the lowest demand niche gets served, then it is possible that $q^w_{RPM}(p^w) = q^w_N(p^w)$. However, the proof of Theorem 1 shows that if F is absolutely continuous, then under RPM the manufacturer can still benefit by lowering the wholesale price.

3   The Welfare Effects of RPM

We have just shown that given the manufacturer's wholesale price, introducing RPM increases retailers' incentives to hold inventories. However, in equilibrium the manufacturer responds to the outward shift in wholesale demand by adjusting the wholesale price optimally. If, as in the example of Section 1, the manufacturer lowers the wholesale price or keeps it the same, then the introduction of RPM necessarily raises equilibrium inventories. However, it is easy to construct examples in which the manufacturer increases the wholesale price, raising the possibility that equilibrium inventories under RPM would be lower than under niche competition. Our next result shows that when demand is rectangular with a common reservation price,

$$d(p,\alpha) = \begin{cases} 0, & \text{if } p > \hat{p} \\ q(\alpha), & \text{if } p \le \hat{p} \end{cases}, \tag{14}$$

this can never occur.

Theorem 3 *Suppose demand is given by (14), with $\partial q/\partial \alpha > 0$. Then equilibrium inventories and welfare are at least as high under RPM as under niche competition. Furthermore, if $c^w < \hat{p}$ and F is absolutely continuous, then equilibrium inventories and welfare are strictly higher under RPM.*

Proof: Under (14), if $p^w < \hat{p}$, equations (11) and (12) become

$$\Pi^w_{RPM} = \max_\alpha \left\{ F(\underline{\alpha})q(\underline{\alpha}) + \int_{\underline{\alpha}}^\alpha q(\theta)dF(\theta) + q(\alpha)[(1 - F(\alpha))\hat{p} - c^w] \right\}, \text{ and} \qquad (15)$$

$$\Pi^w_N = \max_\alpha q(\alpha)\left\{ \hat{p}(1 - G(\alpha)) - c^w \right\}. \qquad (16)$$

Let $\hat{\alpha}$ belong to the arg max in (15), and $\tilde{\alpha}$ belong to the arg max in (16). If $\hat{\alpha} = \bar{\alpha}$, then we clearly have $\tilde{\alpha} \le \hat{\alpha}$. If $\hat{\alpha} < \bar{\alpha}$, then since the maximand in (15) has right-hand derivative $(\partial q(\alpha)/\partial \alpha)[(1 - F(\alpha))\hat{p} - c^w]$ and left-hand derivative $(\partial q(\alpha)/\partial \alpha)[(1 - G(\alpha))\hat{p} - c^w]$, we must have $[(1 - G(\hat{\alpha}))\hat{p} - c^w] \ge 0 \ge [(1 - F(\hat{\alpha}))\hat{p} - c^w]$. But then $\tilde{\alpha} > \hat{\alpha}$ would imply $[(1 - G(\tilde{\alpha}))\hat{p} - c^w] \le [(1 - F(\hat{\alpha}))\hat{p} - c^w] \le 0$, so that by (16), $\Pi^w_N = 0$. Since this contradicts $c^w < \hat{p}$, we conclude $\tilde{\alpha} \le \hat{\alpha}$. Finally, if $c^w \ge \hat{p}$, then equilibrium inventories under RPM and Niche Competition coincide (and are equal to $q(\underline{\alpha})$ if $c^w = \hat{p}$, and zero otherwise).

Next, if F is absolutely continuous and $\hat{\alpha} = \bar{\alpha}$, then $\tilde{\alpha} = \hat{\alpha}$ would imply $\Pi^w_N = 0$, contradicting the assumption that $c^w < \hat{p}$. If $\hat{\alpha} < \bar{\alpha}$, then if $\tilde{\alpha} = \hat{\alpha}$, we would have $(1 - G(\tilde{\alpha}))\hat{p} - c^w = (1 - F(\hat{\alpha}))\hat{p} - c^w \le 0$, again implying the contradiction that $\Pi^w_N = 0$. ∎

Theorem 3 explains why discounting (niche competition) can "impair or destroy the production and sale" of the manufacturer's product by reducing the number of niches served. With inelastic demand, welfare equals expected sales, which are monotone in the level of inventories. Welfare is therefore always higher under RPM. With a common reservation price across states of the world, the RPM price necessarily coincides with the *highest* retail price under niche competition. Hence, so long as more than one niche is served under niche competition, consumers will oppose RPM. Both of these conclusions are strongly tied to the rectangular demand assumption (14). If demand were elastic, then the lower prices available under niche competition would have a welfare benefit. Hence it is conceivable that with elastic demand,

the introduction of RPM would decrease welfare. By the same token, with elastic demand, consumers would benefit from the increased availability brought forth by RPM. It is therefore also conceivable that RPM would result in a Pareto improvement.

To show that each of these cases can in fact occur, we will now analyze the class of examples with multiplicative demand uncertainty and zero cost. Let

$$d(p, \alpha) = \alpha D(p), \tag{17}$$

where the demand curve $D(p)$ has a unique monopoly price p^m, and a choke price $\hat{p}$. Then we have

Theorem 4 *Suppose demand is given by (17), and suppose that $c^w = 0$.[33] Then equilibrium inventories are at least as high under RPM as under niche competition. Furthermore, if F is absolutely continuous, then the inequality is strict.*

Proof: Under the above conditions, the solution to (12) has $p^r = p^m$, and $\tilde{\alpha} \in \arg\max \alpha[1 - G(\alpha)]$. Total retail orders under niche competition are therefore equal to $\tilde{\alpha}D(p^r)$. From (11), it is immediate that the optimal RPM solution consists of charging $p^r = p^m$, with retailers ordering the quantity $\bar{\alpha}D(p^m)$. Since $\tilde{\alpha} \leq \bar{\alpha}$, with strict inequality if F is absolutely continuous, the desired result follows. ∎

Figure 1 depicts the supply curve under niche competition, parametrically defined as $\{(p(\alpha), Y(\alpha)), \alpha \in [\underline{\alpha}, \bar{\alpha}]\}$, together with the supply curve under RPM (under the assumptions that F is absolutely continuous and $\underline{\alpha} = 0$). The tradeoff between niche competition and RPM is immediately apparent. Under niche competition, consumers face lower prices than under RPM for all states of the world $\alpha < \tilde{\alpha}$. However, under niche competition retailers stock less inventory. Hence for demand states $\alpha \in (\tilde{\alpha}, \bar{\alpha}]$, consumer surplus and welfare are higher under RPM. Which effect dominates depends on the relative likelihoods of the different

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[33] In fact, the conclusion of Theorem 4 does not depend on the specific functional form (17). It suffices that the monopoly price $p^m(\alpha)$ is weakly increasing in α, and that the monopoly quantity is strictly increasing in α. In that case we have $p^r \leq p^m(\bar{\alpha})$, and so $q^{RPM} \geq q^m(\bar{\alpha})$. Since $q^N = q^m(\alpha)$ for some $\alpha \leq \bar{\alpha}$, the same conclusion obtains. However, the two state example in Theorem 5 below does exploit the constancy of the revenue maximizing price across states of the world.

(Figure 1 about here)

Figure 1: A Comparison of the equilibrium supply curves under niche competition (S_N) and RPM (S_{RPM})

states, as well as on how close $\tilde{\alpha}$ is to $\bar{\alpha}$ (which in turn depends on the distribution F). While Theorem 4 generalizes the result on equilibrium inventories, our next result shows that the welfare conclusions of Theorem 3 are indeed peculiar to rectangular demand. Consider the two-point distribution

$$F(\alpha) = \begin{cases} 0, & \text{if } \alpha < \underline{\alpha} \\ \omega, & \text{if } \underline{\alpha} \leq \alpha < \bar{\alpha} \\ 1, & \text{if } \alpha \geq \bar{\alpha} \end{cases} \tag{18}$$

Then we have

Theorem 5 *Suppose that (17) and (18) hold, and that $c^w = 0$. Then if $1 - \omega < \underline{\alpha}/\bar{\alpha}$, only one niche is served under niche competition, and expected consumer surplus and welfare are higher under RPM. If $1 - \omega > \underline{\alpha}/\bar{\alpha}$, then both niches are optimally served under niche competition, and expected consumer surplus and total surplus are higher under niche competition.*

The proof of Theorem 5 is immediate. When high demand is unlikely, the manufacturer gives up on the high demand state, and induces the retail price of p^m on the certain niche. Consumers face the same retail price as they would under RPM, but suffer the possibility of rationing, and are worse off. On the other hand, when high demand is sufficiently likely for discount and full price retailers to coexist under niche competition, the discounters transfer surplus from the manufacturer to consumers. Total surplus is higher under niche competition because the discount price induces more purchases in the event low demand is realized.[34]

The results under the two-point distribution (18) are representative of those for general distribution functions, in the following sense. Niche competition reduces consumer and total surplus through the effect of reducing the number of niches served. When the manufacturer chooses a wholesale price (under niche competition) that drives all but the most certain niches

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[34]Our consumer surplus calculations ignore the costs consumers incur in queueing for the chance to buy at low-price retailers, and are therefore biased against RPM.

out of the market, the second effect dominates and everyone prefers RPM. When the manufacturer chooses a wholesale price (under niche competition) that does not drive many niches out, then the first effect dominates and consumers prefer the lower prices available under niche competition.

4   Flexible Retail Prices

Our model of retail competition has assumed that retailers must commit to prices before demand is realized. This assumption is appropriate for markets in which retailers are slow to react to new demand conditions, for example because demand information is slow to reach retailers or because price information takes time to convey to customers. In markets with few constraints on the ability of retailers to adjust their prices, retail market clearing might be a more appropriate assumption. We claim that our theory is reasonably robust to the specification of the mode of retail competition. To illustrate, we show here that the equilibrium wholesale price, inventory level, manufacturer profit, and consumer surplus under market clearing and niche competition coincide when demand is rectangular.

The Flexible Pricing Game is defined by the following timing. First, the manufacturer sets the wholesale price. Next, retailers simultaneously choose how much inventory to hold. Finally, demand uncertainty is realized, inventories are offered to the market, and the retail price is determined by supply and demand.

Theorem 6 *Suppose demand is given by (14). Then for any wholesale price that is potentially profit maximizing, that is, $p^w \in [\hat{p}(1 - G(\bar{\alpha})), \hat{p}]$, the wholesale demand under flexible pricing and niche competition coincides.*

The proof of Theorem 6 is straightforward, and left as an exercise.

The intuition for the equivalence is straightforward, and relates to the intuition for Theorem 2. Under niche competition, expected retail revenues are the same as if all retailers chose the retail price offered by the highest niche (which is the reservation value, $\hat{p}$), but sold only when demand exceeds the aggregate inventory level. But this is exactly what happens to retailers under market clearing when the same aggregate inventory level is supplied to the

market—instead of not selling in the low demand states, the retailer receives a market-clearing price of zero. By avoiding these "fire sales," RPM raises manufacturer profits.

Theorem 6 shows that, at least when demand is given by (14), the manufacturer will choose the same wholesale price and retailers will choose the same inventories under flexible pricing as they do under niche competition. Since total inventories are the same under both regimes, total surplus must be the same. Manufacturer profits are also the same, so consumer surplus must be the same under both regimes. While the equivalence of wholesale demand under niche competition and market clearing breaks down if demand is not rectangular, it is still the case that consumers who are most likely to show up on the market pay a price that is too low from the manufacturer's perspective. Hence the incentive for RPM identified here persists. For a general comparison of RPM versus market clearing, see Deneckere, Marvel and Peck (1995).

5   Applications

Our analysis of RPM and niche competition under demand uncertainty can explain a wide variety of uses of RPM. Markets satisfying the following criteria fit our model particularly well.

1. Demand uncertainty matters: the distribution of demand exhibits significant variation and the realization of demand is unknown at the moment all strategic decisions are made.

2. Adequate retailer inventory holdings are critical to the product's success, and restocking dealers from the manufacturer's inventory is at best an imperfect substitute for substantial initial stocks on the dealers' shelves. This criterion will most often be met for products whose demand period is short, perhaps due to seasonality or perhaps to whimsical or faddish consumers.

3. Demand is not storable and instead evaporates at the end of the demand period. Back-orders are not significant, customers are unwilling to wait for delayed items, or the need for the product in question disappears.

4. Retail prices are slow to adjust to demand shocks, relative to the length of the period in consideration.[35] Period length is determined by requirements (1)–(3).

5. The product does not require significant amounts of dealer pre-sale services that are subject to free riding. This last criterion is not a strict requirement of our theory. We add it to focus attention on products to which free rider explanations do not apply.[36]

In this section, we provide several examples of markets conforming to these characteristics to show that our approach can illuminate RPM uses that are not otherwise readily understood.

As pointed out in the introduction, RPM in the form of minimum advertised price promotions has recently been growing rapidly, and much of the growth has been concentrated in product lines that fit our model criteria well. Past RPM use has also been common for goods with short selling periods and volatile demand. In particular, goods with pronounced seasonality in demand both fit our criteria well and historically have constituted an important locus of RPM use. Examples include goods in demand as holiday, graduation, or wedding gifts, [37] and products whose demand is tied to weather conditions. Indeed, products sensitive to weather conditions exhibit both the uncertainty and inability to store demand that we require. Examples which have been the subject of RPM include lawn and garden equipment,[38]

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[35]It is apparent (Cecchetti, 1985; Carlton, 1986, 1991) that for many products, price changes are infrequent, and that stockouts occur in consequence. Kahn (1992) offers macroeconomic evidence that stockout avoidance is an important motivation for inventory holding. Survey evidence demonstrates that customers anticipate stockouts (Kelly, Cannon, and Hunt, 1991, page 127), a problem thought to be prevalent particularly at discount retailers, consistent with our model. A Federal Trade Commission study, United States Federal Trade Commission, "Trade Regulation Rules Including Statement of its Basis and Purpose: Retail Food Store Advertising and Marketing Practices," July 12, 1971, pages 4–7, found widespread instances of advertised items being unavailable on retail shelves. Availability rates apparently varied substantially from store to store. These findings are consistent with the requirements of our model that firms differ in their stockout behavior and that stockouts be reasonably common for heavily discounted goods.

[36]For examples, see Scherer and Ross (1990) and Winter (1993).

[37]Overstreet (1983, p. 180ff.) reports that jewelry store products subject to price maintenance included watches, pens and pencils, lighters and compacts, silverware, clocks, and china and glass. Ippolito (1991) reports that products involved in RPM disputes between 1976 and 1982 included jewelry, silverware, gourmet cookware, and limited edition plates. For an interesting example of a seasonal product subject at one time to RPM, see "Hartmann Luggage Co.: Price Promotion Policy," Harvard Business School case 581–068, by J.A. Quelch and P.P. Marless, 1981.

[38]Burton Supply Co. v. Wheel Horse Prods. (1974) 1974 Trade Cases ¶75,224. See also the discussion of O.M. Scott & Sons Co. below.

agricultural chemicals,[39] ski equipment[40] and a wide variety of other sporting goods.[41]

The availability of unusually detailed information for one such product makes it particularly appropriate for more detailed consideration. The O.M. Scott & Sons Company had a long history both of RPM use and of concern over the adequacy of retail inventories of its line of lawn care products. [42] In 1959, following a management review, Scotts determined to pursue aggressively expanded distribution for its lawn care line. Scotts had a cautionary example in doing so. Vigoro, a competitor, had been the leading seller of lawn care products, but had lost share after expanding distribution to chain and discount stores.[43] The share loss was apparently due to loss of independent dealers alienated by low prices charged by the chain stores.[44]

> [M]anagement thought that the most important factor standing in the way of further rapid growth and market penetration was the inability of the typical Scott dealer to carry an adequate inventory of Scott products. Because of the highly seasonal character of retail sales of the company's products, it was essential that dealers have enough inventory on hand to meet local sales peaks when they came. ...Failure to supply this demand when it materialized most often resulted in a lost sale to a competitor, although sometimes a customer simply postponed buying.[45]

Dealer-provided services were of decreasing importance in the Scotts marketing mix, and free-riding on such services was not a major threat.[46] Scotts believed that an increasing segment of potential consumers was passing up its traditional outlets to shop at mass merchandisers.[47]

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[39]Ansul Co. v. Uniroyal, Inc., 386 F. Supp. 541 (S.D.N.Y. 1969) and Monsanto Co. v. Spray-Rite Service Corp., 465 U.S. 752 (1984).

[40]See Olympic Distribs. v. Perkins Co. (N.D.Ill. 1982) 1982–83 Trade Cases ¶64,999, with further reference at paragraph 103(a) to a consent decree under which AMF agreed not to continue RPM for Head skis. See also Wurzberg Brothers, Inc., v. Head Ski Col, 276 F. Supp 142 (D.N.J. 1967) and United States v. Olin Ski, 1980-2 Trade Cases ¶63,453, and additional cases cited by Ippolito (1988), p. A-28ff.

[41]Ippolito (1991), table 8 catalogs cases between 1976 and 1982 involving snowmobiles, surfboards, ski equipment, ski apparel, golf equipment, sailboats, diving equipment, and marine electrical equipment.

[42]The discussion of Scotts here is based upon Harvard Business School case 209–102, "The O.M. Scott & Sons Company," 1964, describing a successful but prohibitively expensive attempt by Scotts to increase inventory holdings through liberal credit policies, and on the opinion in an RPM case brought by the U.S. Department of Justice against Scotts, U.S. v. O.M. Scott & Sons Co., 303 F. Supp. 141 (1969) *(Scotts)*.

[43]*Scotts*, p.145.

[44]Ippolito (1991, Table 8)

[45]"The O.M. Scott & Sons Co., Id., p. 2.

[46]Had free riding on dealer services constituted a major threat, Scotts could have increased the direct payments made to dealers for services and promotion that it was already making. Scotts provided advertising allowances, sales clerk training, and assistance in displaying and informing customers about Scotts products. *Scotts,* p. 148. Scotts' sales force inventoried dealers at least twice a month during peak sales seasons, and so could have monitored service provision for purpose of payments to compensate dealers for their sales efforts. "The O.M. Scott & Sons Co.," p. 3.

[47]*Scotts,* p.149.

To tap these customers, Scotts began to improve its package labeling and to expand point-of-sale literature. Even as it developed a marketing channel that did not support provision of presale services, it continued aggressive RPM enforcement.[48] The clear inference is that by doing so, Scotts intended to maintain margins in order to support dealer inventories, as predicted by our analysis.

One recent product introduction will suffice to show that the factors we analyze continue to motivate manufacturers to limit discounting. The introduction of Microsoft Corporation's Windows 95 operating system provides a particularly good illustration of a product that fits our criteria. The product was introduced with a $200 million promotion campaign, an unprecedented figure for computer software and one that meant dealers needed little sales effort to sell the product.[49] Demand forecasting was apparently quite difficult, with sales estimates varying from 12 million to 30 million copies.[50] Actual initial sales are reported to have exceeded retailer forecasts by 30%.[51] Stocks of the product would become obsolete as soon as the first updated version of the software, including bug fixes, was shipped. This update was expected in Fall, 1995.[52] The behavior of Microsoft and its distributors indicates that the product needed to be in the distribution system prior to the beginning of the selling period. It is estimated that by August 24, 1995, the first day on which Windows 95 could be sold at retail, the distribution channel was stocked with between eight and eleven million units, far more than the one million units sold during the first weekend of the retail selling period.[53] Given that the sales projections above include software preinstalled on new computers and direct sales to corporate accounts, inventories exceeded low end demand predictions and therefore constituted a considerable risk. That is, the behavior of Microsoft and its distributors indi-

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[48] Scotts introduced sales to mass market distributors in RPM jurisdictions permitting non-signer clauses. Under such clauses, both a retailer that purchased directly from Scotts and any subsequent dealers were legally bound to maintain Scotts' resale prices. See *Scotts,* at 149. In addition, Scotts attempted to control resales among dealers: "In any decision to expand dealer inventories … management hoped to establish a procedure whereby Scott would retain the right to reclaim goods from third parties if any of its dealers began selling at wholesale to a discounter." "The O.M. Scott & Sons Co.," at 3.

[49] Kathy Rebello, "Feel the Buzz," *Business Week,* August 28, 1995, p. 31, and Jodi Mardesich & Edward F. Moltzen, "First came the hype, then the OS, now it's the promotions," *Computer Reseller News,* August 28, 1995, p. 228.

[50] Don Clark, "Microsoft Says Over a Million Copies of Windows 95 Sold at Retail in 4 Days," *Wall Street Journal,* August 30, 1995, p. B2.

[51] "Computers & Technology: How Goes Windows 95? Sales, Bug Counts Start." *Investor's Business Daily,* August 31, 1995.

[52] Joseph C. Panettieri, "The Launch of Windows 95," *Information Week,* August 21, 1995, p. 28.

[53] Clark, note 50, p. B2.

cates that a policy of waiting until demand was observed prior to filling the retail distribution channel was not feasible.

Microsoft controlled the price at which Windows 95 could be advertised, and thereby effectively controlled the retail selling price,[54] by employing a MAP product promotion scheme. This plan requires that dealers not cut the price below $89.95 in order to be eligible for Microsoft rebates.[55] Microsoft's motive in offering this program was clear:

> the company made the change because WINDOWS 95 is being sold by about 25,000 different retail outlets in the U.S., up from about 12,000 stores in past launches, according to Johan Liedgren, Microsoft's director of channel policies. Many of these retailers would be unable to stock the product if it were widely sold below $89.95, he explains.[56]

Similarly, Microsoft's product manager for Windows 95 said that the MAP promotion was adopted to ensure that the product would have "the broadest possible distribution."[57] Thus, the Windows 95 introduction not only meets our criteria, but also was expected to increase Microsoft's retail distribution coverage, coverage that was seemingly unimpaired by the threat of retailer free riding. Our model provides an answer to the question of how prevention of discounting can result in increased inventory holdings.[58]

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[54]Some discounting was observed by large retail chains such as K-Mart and Wal-Mart, but since their prices were not advertised, these low price sales were trivial. As one Wal-Mart store manager explained the meagre sales performance, "Not many people know Wal-Mart sell stuff like this." See Neal Templin, "Stores Are Plastering Some Sale Stickers Over WINDOWS 95—A Week After Shining Debut, Discounts Are Clearly Seen; It Plays Loss-Leader Role" *The Wall Street Journal,* September 1, 1995, p. B6.

[55]The penalties appear to have been both credible and effective. According to one account, "Nearly all stores were selling the product for the authorized figure of $89.99…The uniformity of …was traced to the fear that if the suggested price were breached, Microsoft would, as one young software clerk cheerfully put it, 'cut our legs off.' A Microsoft spokeswoman said Wednesday that the company had indeed threatened to impose 'pretty serious' sanctions on stores that violated the suggested price. The spokeswoman didn't specifically mention loss of limb." Steve Metcalf, "Windows Shopping, First-Day Buyers Can't Wait to Get With the Program," *The Hartford Courant,* August 25, 1995, p. E1. A Microsoft spokesperson indicated that Microsoft was offering inducements sufficient to enforce their policy: "Will people take this [MAP] seriously? Absolutely. It is tied to their marketing funds." See Joel Shore, "Microsoft: Aug. 24 Ship Date for Next-Generation Desktop," *Computer Reseller News,* June 12, 1995, p. 3.

[56]Templin, note 54, p. B6.

[57]Russ Stockdale, quoted in Elizabeth Corcoran, "Windows Treatment: One Price Fits All; MICROSOFT'S Marketing Agreements Keep Retailers From Discounting," *Washington Post,* August 29, 1995, p. D1. Exactly the same language was used by Microsoft spokesman Liedgren, id.

[58]The "outlets" explanation of RPM (Gould and Preston, 1965) argues that when marginal distribution costs differ across retailers, the manufacturer may wish to vary margins to obtain a denser distribution of outlets than would obtain under competition. Our model does not depend on such cost differences and does not assume that consumers prefer more outlets for outlets' sake. See Reagan (1986) for a formal treatment of the outlets hypothesis.

6 Summary and Conclusions

In this paper, we have addressed the question of why manufacturers wish to prevent retailers from offering their products at heavily promoted discount prices. This behavior appears at first odd, as RPM is often interpreted as a device to encourage promotion. Yet throughout the history of the RPM debate, manufacturers have objected strenuously to discounting.

Our theory does not require that such discounting either mislead consumers or be supported by subsidies generated by higher-margin unadvertised products. Our discounters charge lower prices than their higher price retail competitors simply because their probability of unsold merchandise is lower. However, the mere presence of discounters forces other retailers to increase their markups, as they will find themselves stuck with unsold merchandise more frequently. For a given wholesale price, the higher markups inhibit consumer demand during high demand states, and thereby shift down the wholesale demand schedule facing the manufacturer. In this sense, niche competition destroys demand. By preventing discounting, the manufacturer can induce inventory adequate to service high demand states.

Our analysis identifies a distribution inefficiency that can be mitigated not only with RPM, but also through vertical integration by the manufacturer into distribution. In our model, RPM and a vertically integrated firm charging a single price are equivalent. Our theory thus suggests a new motivation for integration in the presence of demand uncertainty, one which does not rely on differences between manufacturers and dealers in willingness to bear risk. We prefer the RPM interpretation because vertical integration is often an impracticable option for the manufacturer. Retailers upon whom RPM is imposed commonly offer the products of a number of manufacturers. Vertical integration would require that the manufacturer not only open its own retail outlets, but also that it integrate with manufacturers of other goods that those outlets carry, for otherwise those manufacturers would continue to face the inventory problems we have identified.

The free-rider theory of RPM has been employed to support proposals that RPM be made lawful (Posner, 1981). When free riding explains RPM use, it is tempting to dismiss consumer arguments against it as short-sighted desires to take advantage of low prices at free-riding

discounters. In our model, consumer attachment to discounting makes more sense, since these discounters are free-standing, not reliant on the promotional efforts of full-price competitors. Whether RPM increases welfare depends on the impact of discounting on total inventory holdings. We have shown that discounters can indeed act as "knaves" that "impair, if not destroy, the production and sale of articles," and have thereby shown that RPM can be welfare-enhancing. But we have also shown that RPM will be employed even where discounting would not have seriously impaired distribution, and in such cases would diminish welfare. Which of these effects would dominate were RPM legal is, of course, a difficult empirical question. But it is clear that the discount-prevention argument for RPM, so popular with manufacturers yet seemingly so at variance with sensible economics, does merit careful consideration.

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Price

S_N S_{RPM}

p^m

p^w

$\tilde{\alpha}D(p^w)$ $\bar{\alpha}D(p^m)$ Quantity